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## REGENERATION IN THE PLANARIAN PHAGOCATA GRACILIS.

T. H. MORGAN AND ALICE E. SCHIEDT.

*Phagocata gracilis* differs from other planarians in having a number of pharynges in a common pharyngeal chamber. There is a large median anterior pharynx, and 12 or 14 lateral pharynges arranged along the sides of the chamber. The object of the following study was to determine the sequence in the regeneration of the pharynges in pieces from different regions of the body. The particular point that we had in view in beginning the work was to examine the origin of the new pharynges in pieces cut posterior to the region of the old pharynges. It has been shown for other planarians that pieces from this region of the body produce a new pharynx at or near the anterior end, and the question arose as to what would occur in a form like *Phagocata* having several pharynges. Would the median pharynx first appear and new ones be added behind this one? This would indicate that a growing region was also present *behind* the first pharynx, while in other planarians the growing region in pieces of this kind appears to be mainly anterior to the new pharynx. It seemed not improbable that a single anterior pharynx alone might develop and produce a mono-pharyngeal worm! Other similar questions arose in connection with the regeneration of new lateral pharynges in more anterior pieces.

The regeneration of the pharynges, in cross-pieces from the following regions of the body, was studied:

- A. Worm cut transversely into five pieces.
  1. Head-piece without any pharynges.
  2. Median piece with old median anterior pharynx.
  3. Middle piece with several lateral pharynges.
  4. Posterior piece with posterior pair or pairs of lateral pharynges.
- 5. Tail piece without any pharynges.
- B. Worm cut transversely into ten pieces.

C. Worm cut transversely into three regions : (i.) head, (ii.) region of pharynges, (iii.) tail piece. These three pieces were again cut transversely into as small pieces as possible.

An examination of the position of the new pharynges in the different pieces showed that in head-pieces the development occurred in the posterior part of the piece. In middle pieces new pharynges were regenerated at both ends ; and in tail-pieces a new median pharynx appeared in the anterior part and new lateral ones were later added behind.

The first series (A) of preparations (sections) were of worms cut into five pieces and killed ten days later.

Five head-pieces : (i.) has a large central pharynx, four lateral pharynges, three on the left, one on the right.

(ii.) A central and three lateral pharynges are formed.

(iii.) A central and two lateral pharynges are regenerated.

(iv.) Four pharynges are formed ; the largest is probably the median pharynx, but this is not certain because the piece had a peculiar shape, due to unequal cutting.

(v.) A central and four lateral pharynges are formed.

Five median pieces with the old central pharynx present.

(i.) The old central pharynx appears and five new lateral ones.

(ii.) An old central pharynx and, owing to imperfect cutting, old lateral ones are also found ; three new lateral pharynges have regenerated.

(iii.) An old central pharynx and many new lateral ones are present.

(iv.) No old pharynx is found in this piece ; a new central and three new lateral ones are formed.

(v.) An old central pharynx and possibly two or three lateral ones are left. There are several new lateral ones.

Five middle pieces. (i.) shows a new central pharynx and lateral ones anterior and posterior—the old lateral ones occupying the middle of the piece.

(ii.), (iii.), (iv.), and (v.) show a similar regeneration.

Of the five posterior pieces (i.), (iii.), and (v.) were cut too far back, and therefore only new pharynges are found. There are present a central and several lateral ones.

(ii.) and (iv.) have old lateral pharynges, and a new central pharynx and new lateral ones both anterior and posterior.

All the tail pieces show a new central pharynx and from two to five new lateral pharynges.

The second set of worms were cut into five similar pieces and killed at the same time as the first set.

Of the three head pieces (i.) and (iii.) show a new central and four new lateral pharynges.

(ii.) shows a central and three new lateral pharynges.

The median pieces all have a new central pharynx growing probably from the base of the old one. They all have several new lateral pharynges ; and worms (ii.) and (iii.) have two lateral old pharynges.

Each of the middle pieces shows many old lateral pharynges. (i.) shows one new lateral pharynx in the posterior end ; (ii.) shows two new anterior and one new posterior pharynx ; (iii.) and (iv.) show a new central pharynx and lateral ones anterior and posterior.

The posterior pieces (ii.) and (iii.) show a new central and new lateral pharynx in the anterior part, old lateral ones in the middle, and new lateral ones posteriorly.<sup>1</sup> (ii.) shows only a new central pharynx ; the rest are old. Of the tail-pieces, (i.) has a new central and five new lateral pharynges. In (ii.) no new pharynges have regenerated.

In (iii.) a new central and two lateral pharynges have developed.

The third set, cut into five pieces, were killed twelve days after the worms were cut.

The three head-pieces show a new central and four new lateral pharynges.

Of the median pieces (i.) and (iii.) show an old central and three new lateral pharynges. (ii.) has regenerated two new lateral ones posteriorly ; the four others, including the central one, are probably old ones.

The new central and several old lateral pharynges are present in the middle pieces ; new lateral ones are developed at both ends of the pieces.

Of the posterior pieces (i.) has one old and two new pharynges ; the central one is not yet regenerated.

<sup>1</sup>In this case it is probable that the cut removed some of the old posterior pharynges.

(ii.) has no old pharynges ; but two new ones, one of which is the central pharynx. (iii.) has no old lateral pharynges in the posterior part, three new anterior ones, including a new central pharynx. Each of the tail-pieces has one new pharynx ; (ii.) has also one lateral pharynx-bud.

In another series (B) the planarians, cut into ten pieces, were kept ten days before being killed.

(a) The head-pieces died with but one exception. In this a pharynx cavity is formed with, possibly, a pharynx-bud.

(b) The second pieces except worm (ii.) show new pharynges regenerated.

(iii.) and (iv.) have developed a new central and four new lateral pharynges.

(i.) has a central and three lateral pharynges.

(c) The third pieces all have a new central pharynx and from one to three new lateral ones. In one piece the anterior pharynx is probably the old one.

(d) The fourth pieces show new pharynges regenerated at at each end of the pharynx cavity, there being old ones in the middle. (i.) and (iii.) have a new central pharynx and several new lateral posterior ones, and several old ones in the middle.

(ii.) differs in having other new pharynges besides the central one in the anterior part.

(e) The fifth pieces are similar to the fourth, having new pharynges at both ends, old ones in the middle.

(f) Two of the sixth pieces have four new lateral pharynges posteriorly, the central one and the three anterior lateral ones being old.

(iii.) has a central and two lateral pharynges, probably all of them new.

(g) All of the seventh pieces have a new central pharynx, old ones in the middle and new ones towards the posterior end.

(h) One worm of the eighth set shows a condition similar to those of the seventh set. The other has only new pharynges, a central and two lateral ones.

(i) The ninth pieces have two or three new pharynges, (i.) has a central one, while in (ii.) no central pharynx has regenerated. No old ones are left.

(j) Two of the tenth pieces have not formed new pharynges, the third has a new central and two new lateral pharynges.

In another series (C) the planarians were cut into the three regions of the body—head, pharyngeal and tail parts and then each of these were cut into very small cross-pieces; they were kept nineteen days and then killed. In the head pieces a new central and from three to five new lateral pharynges have developed.

The pieces from the pharyngeal region give no results as the pharynges are too advanced for one to be able to determine which of the pharynges are old and which are new.

One of the tail pieces had no pharynges developed. The others had a central and from four to six new lateral pharynges regenerated.

The only other study that has been made of the regeneration of *Phagocata gracilis* is that of Lillie in 1901.<sup>1</sup> He showed that "the power of regeneration of this genus is equal to that of *Planaria*." He also pointed out that in cross-pieces several pharynges regenerate simultaneously, although the more anterior ones are the most advanced. Each pharynx develops at first in a separate cavity of its own and the cavities fuse together to form a common pharyngeal cavity. We have also observed this mode of development. Lillie found that in lateral pieces new pharynges first arise on the old side of the piece and the new ones on the opposite, regenerating side do not appear until a branch of the intestine has extended into this region. The new pharynges connect at one end with this branch.

#### CONCLUSIONS.

The regeneration of cross-pieces from different levels shows the following relations.

1. Pieces anterior to the old pharyngeal chamber produce in the new tissue at the posterior end a new median pharynx and lateral pharynges that increase in number from before backwards.
2. Pieces containing only the old median pharynx develop new lateral ones from the sides of the pharyngeal chamber.

<sup>1</sup> Lillie, F. R., "Notes on Regeneration and Regulation in Planarians," *Amer. Jour. Physiology*, VI., 1901.

3. Pieces containing only some of the lateral pharynges develop a new median pharynx at the anterior end of the pharyngeal chamber and new lateral pharynges both in front of and behind the old lateral pharynges.
4. Pieces cut behind the old pharyngeal chamber develop a new median anterior pharynx and new lateral ones are added from before backwards.
5. Old lateral pharynges do not appear ever to be substituted for the old median pharynx if this is removed.